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DEBRIS CONTROL AT HYDRAULIC STRUCTURES IN SELECTED AREAS OF THE USA

by

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Second Interim Report

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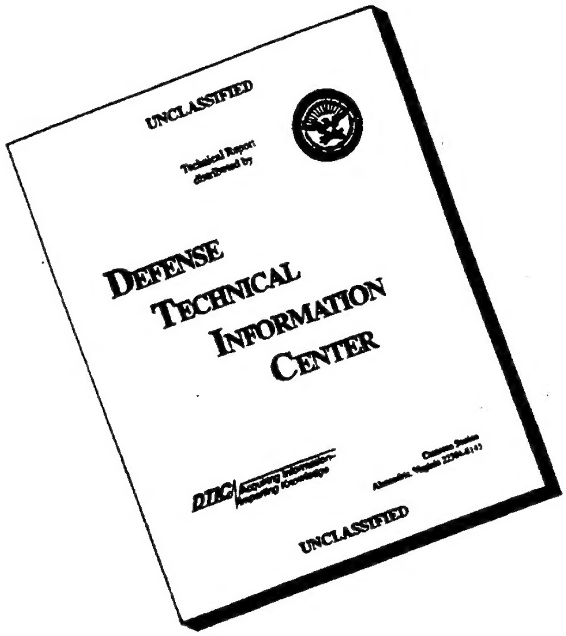

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INTRODUCTION

This second interim report documents field visits and interviews that have been carried out, in Eastern, Central and south Central USA, by Prof. S. R. Abt of Colorado State University to determine some of the alternative means and methods that are employed for the management of debris and drift in navigable waterways.

The site visits were performed as follows:

Corps District	Location	Dates	Primary Contact
Huntington	Huntington, WV	5 SEP 95	Mr. Jon Fripp
Vicksburg	Monroe, LA	17 OCT 95	Mr. C. L. Corken
St. Louis	St. Louis, MO	8 NOV 95	Mr. Billy Arthur
Louisville	Louisville, KY	9 NOV 95	Mr. Gene Allsmiller

A comprehensive list of contact names and addresses is presented in Enclosure 1.

The general findings of this report, and those of the European research effort which have been submitted as the first interim report, will be combined to produce a final document that outlines a set of best-practice guidelines for floating debris management at run-of-river hydraulic structures.

Huntington District

On 4-5 SEP 95, I traveled to Huntington, West Virginia, to meet with Mr. Jon Fripp and Mr. Sutten Epps of the Huntington District, U. S. Army Corps of Engineers. The focus of the meetings was to discuss the debris and drift problems they currently experience at the Bluestone Dam. Bluestone Dam is an instream structure on the New River located approximately 40 miles southeast of Charleston, West Virginia. The dam is the second structure in a series on the river;

Claytor Lake Dam is immediately upstream. The reservoir provides flood control and recreation benefits to the region.

The Bluestone Dam is a concrete structure that completely spans the width of the New River Valley thereby intercepting all tributary flow. Flow is passed through the dam with a series of intake wells and tunnels that span the upstream dam face. Emergency spillways regulated by tainter gates span the top of the dam crest. The dam was constructed in 1947.

The upper New River basin is characterized by a mountainous, wooded terrain that is subjected to intense rainfall-runoff events. The combination of Claytor Lake Dam releases with tributary runoff resulting in flood water hydrographs that can rise from pool level to flood stage in an extremely short period of time (12-48 hours). Vast quantities of debris and drift routinely accompany the rising limb of the flood hydrograph. The debris and drift are usually allowed to accumulate until a sufficient mass debris develops that can be efficiently flushed through the dam. Approximately 8 to 20 acres of debris and drift accumulate at least once annually. It is not unusual that 8,000 to 15,000 tons of debris may collect in a single event. A summary of events and estimated drift accumulations (acres) are presented in Enclosure 2 for the period 1982 through early 1995.

On September 5, 1995, I was escorted to Bluestone Dam to observe the site and meet with Mr. David Eskridge, Dam Operations Supervisor. Mr. Eskridge indicated that debris passage and cleanup were addressed by several means.

1. All plastic and manmade debris were routinely collected using a motorized barge. Only woody debris and drift were passed through the dam intake.

2. Debris and drift that accumulate along the shoreline adjacent to the dam were periodically collected by a government contractor.

3. Small debris and drift accumulations (<< one acre) may occasionally be collected using a grapple or barge mounted clamshell.

4. The most common means of passing the debris and drift through the dam is by a coordinated flushing operation linked to the peak and recession limb of the flood hydrograph. Debris is usually allowed to accumulate until a major storm event occurs. The maintenance staff is alerted when Claytor Lake Dam is about to release flood water. When the flood crest approaches Bluestone Dam, one of the intake towers is opened and all flow is released through the single intake. The inflowing debris is allowed to accumulate against the face of the dam. The motorized barge with the clamshell is used to manage and guide the debris toward the intake. Large debris accumulations (10 acres or more) require 3 to 21 days to route the debris mass through the dam.

The larger debris accumulations span the width of the river valley and wedge against the dam face. A photograph of the March 1993 flood event is presented in Enclosure 3. Approximately 40 acres of drift and debris are observed prior to passage. In addition, a photograph illustrating the January 1995 event demonstrates how the debris compacts against the dam face. Approximately 35 acres of debris accumulated during the January flood.

The debris passage is coordinated with the flood hydrograph to provide sufficient flow to carry the debris downstream. Approximately eight miles downstream of Bluestone Dam are the Bluestone Falls, a state preserve area. Debris often collects on or near the Falls, which, in turn, angers local citizen and environmental groups. Public relations and environmental concerns have guided debris passage operations.

The Huntington District is developing and designing a debris bypass modification to the Bluestone Dam. A series of debris intakes may be placed near the center of the dam (larger than the intakes currently used). A new barge (with crane) and rake are proposed for managing/guiding the debris to the intakes. Debris passage will continue to be coordinated with the flood hydrographs.

Vicksburg District

On October 16-17, 1995, I traveled to the Monroe Area Office of the Vicksburg District and met with Mr. Corkey Corkern, Area Supervisor. The debris and drift related problems are directed to lock and dam operations throughout his area of responsibility. Mr. Corkern escorted me to the Columbia Lock and Dam where I was afforded a tour of the facility. In addition, I was allowed to interview Mr. Ray Shumaker, Lockmaster of the Columbia Lock and Dam, Mr. Doug Prudnomme, Lockmaster of the Jonesville Lock and Dam, and Mr. Fred Pittman, Lockmaster of the J. H. Overton Lock and Dam.

A Lock and Dam is a structure designed to maintain sufficient in-channel flow depths that allow a river channel to be navigable. The dam spans the width of the river and creates a backwater pool that permits navigation. To permit the passage of flood waters, regulated and unregulated weir crests control minimum stage levels. Tainter gates are often placed atop the dam crest, which allows the operator to manage appropriate stage-discharge levels during high water stages. The lock is usually situated adjacent to an abutment of the dam and the river bank. The lock is a hydraulically operated channel that extends through the dam. The lock entrance and exits are controlled by miter gates. A system of pumps is used to manage the water surface in the lock to align with upstream and downstream water surface elevations. The lock permits the passage of maritime vessels through the dam.

Common problems related to debris and drift in lock and dam operations include:

1. Debris accumulation in the lock approach, often debris is trapped against the miter gates.

2. Conveying the debris through the lock. Debris often wedges into hydraulic systems, pipes, and cables in the gate and lock areas.

3. Debris gets caught in the outlet works of the lock after being conveyed through the lock.

4. Debris accumulates adjacent to the dam and tainter gates.

5. Debris often accumulates in the tainter gate during the flushing operations. In addition, debris may damage the tainter gates (i.e., removing paint, protective covers, etc.) during flushing. Extensive corrosion often results from the damage.

6. The lock and dam is occasionally overtopped. Debris accumulates in the overbank areas and must be collected.

Because of the unique design and operational aspects of each lock and dam, each lockmaster has developed a customized approach to debris management. A brief summary for each of the three lock and dam operations will be related.

Columbia Lock and Dam

Mr. Ray Shumaker, Lockmaster, provided a tour of the Columbia Lock and Dam located on the Ouachita River, 30 miles south of Monroe, Louisiana. The structure consists of a dam with an unregulated weir and spillway with four tainter gates (26 feet high). The dam abuts to the lock that is 1,200 feet in length and 84 feet wide. Miter gates control the lock entrance and exit.

Debris and drift are routinely conveyed down the river. Prevailing flow patterns and winds direct the majority of the debris toward the lock operation. Debris accumulations are quite frequent during passage of flood hydrographs. When debris and drift accumulate in sufficient quantity that it impacts vessel passage, a "mule" barge is used to guide the debris to the miter gate entrance. Air bubblers have been installed at the miter gate to keep debris from the gate face and recess to allow the gate to fully open. The miter gate is opened and the barge pushes the debris into the lock. The barge conveys the debris through the lock and releases the debris into the river channel at the outlet. It is estimated that the barge is used 10 to 12 times per year. The debris clearing operation usually takes two to three hours.

When debris and drift are trapped upstream of the tainter gates, the lockmaster manipulates the tainter gates to flush the debris through the structure. A crane may be used to remove debris that collects in the gate support structure.

Approximately once every two to four years, the flood water stage overtops the lock and dam structure. Normally, sufficient lead time is provided to allow the maintenance crew to remove all handrails, signage, and other portions of the structure that will collect and/or retain debris during the flood. This is a major effort. Debris and cleanup operations begin during the falling limb of the flood hydrograph. Debris deposited in the overbank areas is collected by government contract personnel. Post flood cleanup may take several months to complete.

Jonesville Lock and Dam

The Jonesville Lock and Dam is located on the Black River Southeast of Monroe, Louisiana. Mr. Doug Prudhomme, Lockmaster, traveled to the Columbia Lock and Dam site to meet with me and discuss debris maintenance operational procedures. The Jonesville Lock and Dam consists of a hinge crest spillway, control crest with five tainter gates, and a lock 600 feet long and 84 feet wide.

During flood stage, debris and drift accumulate on the upstream face of the dam. Debris is not routed over the spillway. Therefore, drift is guided to the lock and pushed through with a barge (with trash rack) or with two skiffs pushing a log ram. Bubblers have been installed at the lock miter gates to keep debris from impacting gate opening and closing operations. Occasionally, booms are placed upstream of the miter gates to divert debris from the lock chamber. High water events often requires that a crane be used to clamshell debris from the structure near the tainter gates.

High water events (flood levels) occur two to three times per year. When high water is predicted, the rails along the lock chamber are removed. Debris is frequently caught in the pipes, cables, and motor pits in the lock chamber. Debris removal is often performed using a spike pole when maintenance personnel are available.

Enclosure 4 illustrates a typical debris jam in the Jonesville Lock (March 21, 1995). Drift has been observed to nearly fill the 600-foot lock.

J. H. Overton Lock and Dam

Mr. Fred Pittman, Lockmaster of the J. H. Overton Lock and Dam, traveled to the Columbia Lock and Dam site with me to discuss debris management operations. The J. H. Overton Lock and Dam was constructed in 1987 and is situated on the Red River. There is not a spillway on the dam. The dam has not been overtopped during high water levels as has the other lock and dam sites. The dam crest is controlled by a series of tainter gates. The approach

channel was constructed with submerged dikes in the upstream channel. The dikes divert flow away from the lock entrance. Thereby debris is carried into the dam and tainter gates.

The vast majority of the debris is conveyed through the dam tainter gates. On occasion, one to two acres of debris will buildup along the dam face and must be removed using a barge mounted crane. When debris collects at the miter gates, bubblers are operated to suspend the debris away from the gate. The miter gates, in sequence, are operated and a "mule" barge with rake conveys the drift through the lock. Debris is continually caught in the sidewall ports of the lock. Spike poles are used to free the debris.

Summary

Each lock and dam either flushes the debris through the tainter gates, over the spillway, or through the lock chamber. Booms or dikes are routinely used to divert debris to the desired area for conveyance through the dam. "Mule" barges, or similar apparatus, are employed to guide drift through the lock chamber. Cranes are used for specialized debris removal. Debris management and/or removal operations are considered a portion of routine operations and maintenance. Enclosure 5 illustrates the extent of debris accumulation that can occur during an average flood season.

St. Louis District

On November 8, 1995, I met with Mr. Billy Arthur in the St. Louis District Office. Our discussion focused on his knowledge of debris problems and management in the district.

Mr. Arthur indicated that nearly all problems addressed in the district office related to lock and dam operations on the Mississippi River. Debris management is the responsibility of the lockmaster. Financial resources are not directly allocated for debris/drift operations. Debris is considered a part of the routine maintenance and operational budget. Emergency funds can be allocated on an "as needed" basis.

The majority of the lock and dam operational problems are related to ice jams, ice breaking, and ice damage. In comparison, debris is a minor concern. Most of the district efforts have been aimed at the design and installation of bubbler systems employed to keep debris away from the miter gates during opening and closing operations.

Louisville District

On November 9, 1995, I traveled to Louisville, Kentucky, to meet with members of the Louisville District Office. Discussions were oriented toward debris problems at reservoirs and at lock and dam operations. Mr. Rick Morgan and Mr. Gene Allsmiller were the principal contacts.

Reservoir Operations

Buckhorn Reservoir located in east Kentucky was the only reservoir the staff considered having debris concerns. Buckhorn is a run of river dam that spans the river valley. Debris is not passed over or through the dam. A boom is placed in front of the dam intake structures. Prevailing winds push the debris toward the abutment of the dam adjacent to a boat ramp. The boom is periodically retrieved thereby directing the debris to the shore line. A crane is employed to retrieve the debris and stack it along the shore. The debris is cut, piled, and burned on a periodic basis.

On occasion, debris will become water logged and float under the log boom. The debris will enter the intake tower and jam. A diver in conjunction with a barge mounted crane is needed to clear the debris from the intake. The diver is used every two to three years.

Lock and Dam Operations

The Louisville District supervises 14 lock and dam operations (8 on the Ohio river, 2 on the Green River, and 4 on the Kentucky River). The size of each lock and dam varies considerably. Most of the operations were designed to pass major flood events without overtopping. All operations attempt to flush debris through the lock and/or dam. Two items were noted that were unique from other lock and dam operations and warranted citation.

Markland Lock and Dam is located on the Ohio River 531.5 miles below Pittsburgh, Pennsylvania (see Enclosure 6). The right abutment contains an intake for five hydroelectric power units. During spring runoff and high water levels, a large debris buildup occurs (no areal estimate) at the hydro-power intakes. Debris removal is performed with booms, tainter gate manipulation and flushing, and crane removal. This is the only lock and dam with operational hydro-power capability. Extensive care is taken to protect the hydro-power units from debris clogging and buildup.

Circumstances were noted in our conversation in which debris was credited with disrupting barge operations. When large debris buildups occur, towboats have reported that debris fouls the engines and/or rudders. Situations were cited where the towboat and/or barge impacted the dam and/or lock chamber, and in some instances sank. Specific documentation of these cases was not made available. However, cases exist in which debris was credited for excessive damages to barges, towboats and subsequently the lock and dam structure. Repairs, cleanup, and/or remediation are considered events worthy of emergency or contingency fund allocations.

In August 1995, the Louisville District, Corps of Engineers, in conjunction with other Corps Districts, conducted a study on debris accumulation for Ohio River lock intakes. The memorandum recording the findings of the study is presented in Enclosure 7. The report

concluded that the amount of debris accumulation around intakes depends on the orientation and location of the locks, and the clearance between the inverts and river bottom. Debris routinely enters the lock chamber and integrates into the side ports, pipes, cables, and motor wells. Maintenance and debris removal is not routinely performed. The Corps is proposing a modification to the lock that will impact lock filling time and potentially impact debris buildup in some locations of the chamber. A model study is being performed by the U. S. Army Engineer Waterways Experiment Station on the proposed lock modification. The results of the study are not available at this time.

Summary

During the Fall of 1995, I visited four U. S. Army Corps of Engineers District areas in the east, central, and southcentral portions of the United States. Personnel were interviewed and site visits were performed to determine some of the alternative means and methods that are employed for the management of debris and drift in navigable waterways. Primary debris accumulation problems occur in reservoirs and in lock and dam operations. Debris flushing and/or removal procedures presented are considered state-of-the-art. Little interest or incentive was perceived in elevating the state-of-the-art at the district level. Field personnel are open to new suggestions and/or procedures for managing debris, however, there will be resistance to implementation if there is an impact to their limited maintenance resources.

It is evident that each district perceives debris management from a different perspective. Debris management received considerable attention in the southcentral U. S., particularly where ice is not considered a major concern. However, debris management is a secondary concern compared to ice in the north and eastern U. S.

Recommendation

It is recommended that at least three additional districts be visited prior to the conclusion of the data gathering portion of the study. The upper Missouri River Basin, the Sacramento River basin, and a basin in the Pacific northwest may warrant site visits to provide a full spectrum of debris management procedures within the U. S. Army Corps of Engineers.

Enclosure No. 1

Enclosure 1

CONTACTS

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Enclosure No. 2

Enclosure 2

BLUESTONE LAKE - DRIFT WORK

1 January 1982 thru 6 December 1993

1982	DAYS WORKED	ACRES*	NOTES
7-8 January	2	EST 2	
8-11 February	4	EST 6	
11 March - 7 April	17	EST 25	
15-24 June	6	EST 8	
16 July	1	**	

1983	DAYS WORKED	ACRES*	NOTES
19-24 February	6	EST 10	
13 May-20 June	15	EST 20	
23 July	1	**	
27-29 September	3	EST 4	
26 October	1	**	

1984	DAYS WORKED	ACRES*	NOTES
18 February - 2 April	21	EST 30	Sea Crane installed on barge 2 March. First used on 5 March 1984.
14-17 May	4	EST 12	
5-9 November	5		Lowered pool to 1400.50 (SD 511). Drift removed from trash racks 3 feet below surface to 1397.00.

Enclosure 2

1985	DAYS WORKED	ACRES*	NOTES
28 February - 5 March	6	EST 20	
21 March	1	**	
23 April	1	**	
20 August	1	EST 2	
17-18 October	2	EST 5	
11-14 November	3	EST 10	
27 November	1	**	
17 December	1	EST 2	

1986	DAYS WORKED	ACRES*	NOTES
3-6 January	2	EST 4	
18-20 March	3	5	
23 June	1	EST 2	
24-29 October	2	EST 5	

1987	DAYS WORKED	ACRES*	NOTES
14 January	1	EST 2	
17 March - 2 April	9	EST 35	
4-7 May	4 Double Shift	40	
21 May	1	**	

1988 No reference to drift work in project records.

Enclosure 2

1989	DAYS WORKED	ACRES*	NOTES
23-24 May	2	EST 5	
18-20 July	3	EST 8	
18-21 September	3	EST 8	
24 September	0	20	Drift accumulated after Hurricane Hugo. Decision made to do test removal by crane.
3 October	0	3 additional	

1990	DAYS WORKED	ACRES*	NOTES
3-7 January	0	14 additional	
6-7 March	2	1/4 acre removed (252 ton)	Test removal with 90 ton mobile crane. Water restriction at 30% due to compacted drift.
12 March - 3 April	12		

1991 No drift worked or accumulated.

1992	DAYS WORKED	ACRES*	NOTES
3-4 February	2	1	
2-4 March	3	5	
27 April - 6 May	8	25	
11-18 June	6 Double Shift	32	

Enclosure 2

1993	DAYS WORKED	ACRES *	NOTES
5-12 March			137.5 man hours used to pick trash from 7 acres of drift. Approx. 15% of trash removed amounting to 6 to 7 pickup loads.
16-18 March	3	7	
13-20 April	8 Double Shift	46	
5-6 December Drift accumulated	Not passed	1	106.5 man hours used to pick all trash from 1 acre of drift. Trash removed 16 vehicle tires, 1 tractor tire and approx. 13 cu. yds. (1.03 ton) of other trash.

Enclosure 2

1994	DAYS WORKED	ACRES*	NOTES
29-31 January	Not passed	1	
12-13 February	Not passed	3	169 man hours used to pick trash from 3 acres of drift. Trash removed: 21 vehicle tires, 2 propane tanks and approx. 16 cu. yds. (1.92 ton) of other trash.
15-16 March			Drift Exercise and Flow Study with Painted Drift.
30-31 March	Not Passed	5	
8-31 August			Drift Removal and Chipping Contract
18-19 August		1 1/2	Removed during contract.

* Reference to acres of drift is after a few days compaction has occurred. Acreages were calculated unless EST is indicated. Any acreage listed as EST is based on project personnel knowledge of time required for drift removal.

** Most references to 1 day of work are likely cleanup of additional material which floated from the bank after initial removal.

Enclosure 2

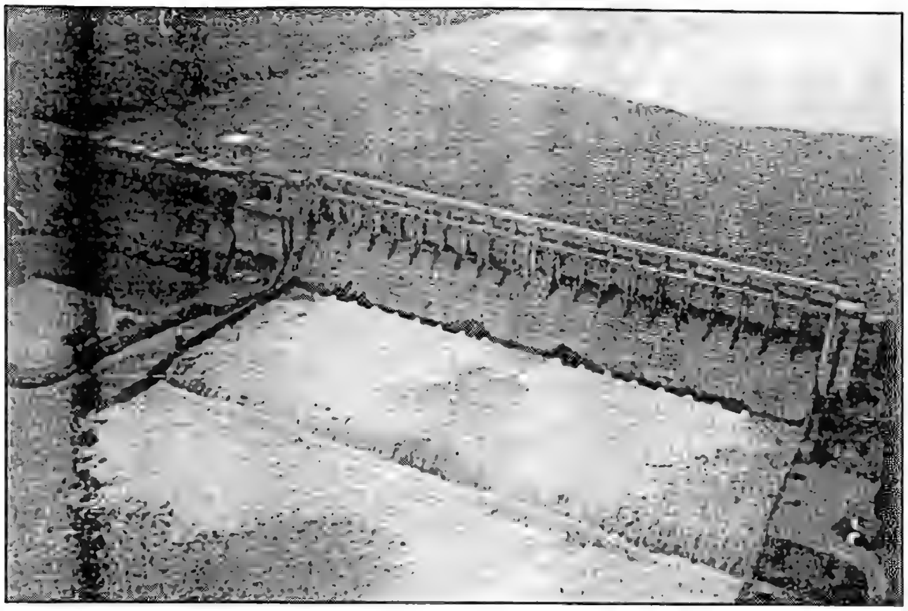
1995	DAYS WORKED	ACRES*	NOTES
15-17 January		32	
18-20 January			143 man hours used on barge and jon boat to remove approx. 1 ton of bagged material; 24 tires, 4 barrels & 2 vehicle gas tanks. Corps and contract personnel used. Cannot tell where trash was removed.

* Reference to acres of drift is after a few days compaction has occurred. Acreages were calculated unless EST is indicated. Any acreage listed as EST is based on project personnel knowledge of time required for drift removal.

** Most references to 1 day of work are likely cleanup of additional material which floated from the bank after initial removal.

Enclosure No. 3

Enclosure 3



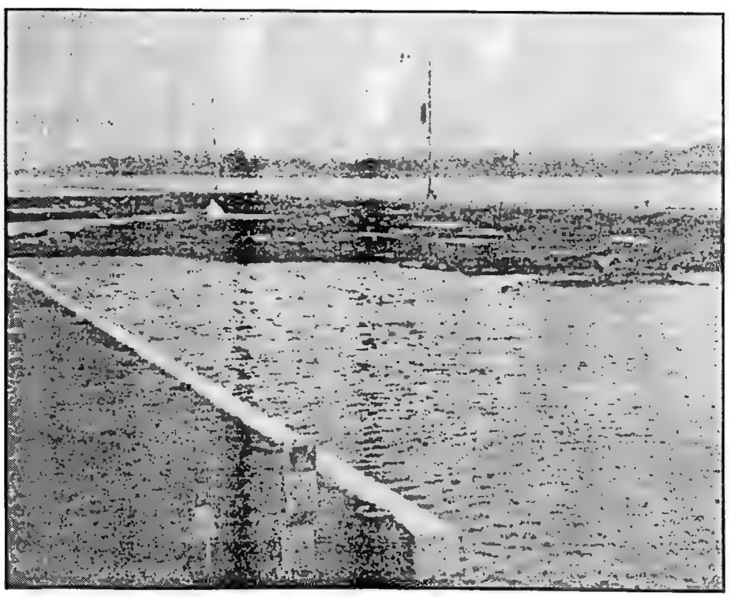
Bluestone Dam, March 1993, Flood Event

Bluestone Dam, January 1995, Flood Event

Enclosure No. 4

Enclosure 4

Black River, March 1995



Black River, March 1995

Enclosure No. 5

Enclosure 5

Typical log jam, Lock and Dam Operation

Typical log jam, Lock and Dam Operation

Enclosure 5

Typical log jam, Lock and Dam Operation

Typical log jam, Lock and Dam Operation

Enclosure No. 6

Enclosure 6

BENEFITS

The 1200-foot long lock chamber of the Markland Locks enables tows to pass in one operation instead of having to break up and lock through in smaller sections.

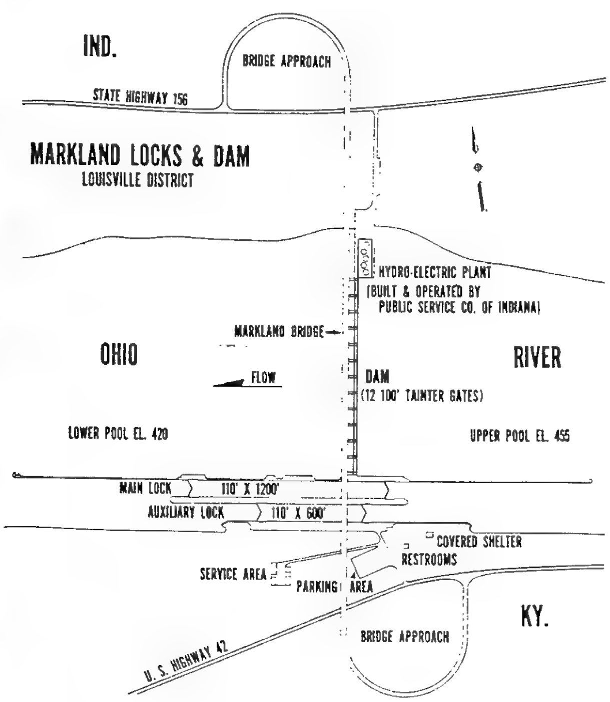
The Markland Locks and Dam has replaced five outmoded locks and dams with one modern structure, thus reducing travel time because only one lockage is required instead of five.

Faster lockage through the new structure due to floating mooring bitts and eight-minute filling or emptying of the lock chambers.

Reduction of annual operation and maintenance costs because one lock and dam replaced five existing structures.

Reduction of annual channel maintenance dredging formerly required in the old low lift pools.

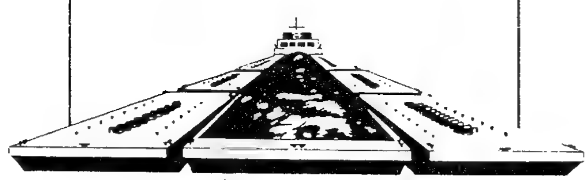
The deeper, wider and more stable pool formed by the Markland Locks and Dam permits more efficient operation of towboats and enhances the efficiency of terminal operations in the area.



Markland
Locks & Dam

The Ohio River...

...Artery
of
Development



US Army Corps
of Engineers
Louisville District

Enclosure 6

LOCATION

The Markland Locks and Dam is located on the Ohio River at mile 531.5 below Pittsburgh, Pennsylvania. It is 26-1/2 miles upstream from Madison, Indiana and 3-1/2 miles downstream from Warsaw, Kentucky. The navigation locks are located on the left bank or Kentucky side of the river. The upper pool above the dam extends upstream for a distance of 95.3 miles to the Meldahl Locks and Dam at mile 436.0 and for a short distance up three navigable tributaries – the Miami, Licking, and Little Miami Rivers.

STATISTICAL INFORMATION

DAM

Type . . . . Tainter gate
Length . . . . 1,395 feet
Upper pool elevation
(above sea level) . . . . 455.0 feet
Lower pool elevation
(above sea level) . . . . 420.0 feet
Number of gates 12
Height of gates . . . . 42 feet
Width of gates . . . . 100 feet
Clearance of gates above
maximum high water when
fully raised . . . . 5 feet

LOCKS

Number 2
Location . . . . Along left bank
Lift . . . . 35 feet
Size of main lock
chamber (in feet) . . . . 110 x 1,200
Size of auxiliary lock
chamber (in feet) . . . . 110 x 600

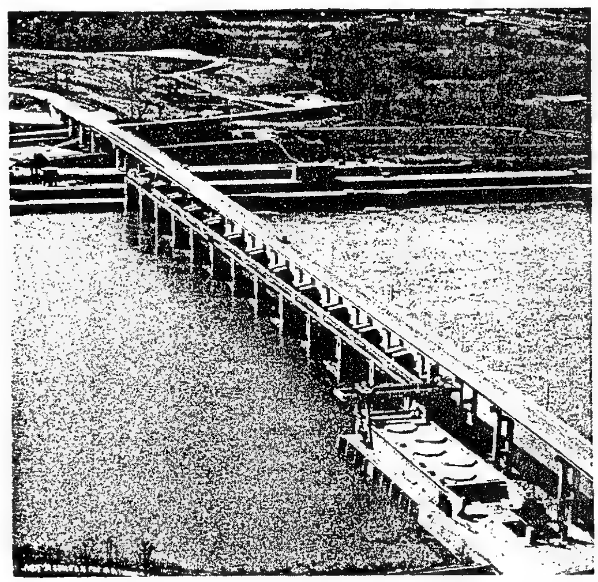
WATER SAFETY....

THE DIFFERENCE BETWEEN

LIFE AND DEATH!!!

HYDROELECTRIC POWER PLANT

Under license granted by the Federal Power Commission, the Public Service Company of Indiana constructed and operates a run of river hydroelectric power plant at Markland Dam. Capacity of the plant is 81,000 kva. Operation of the plant is fully compatible with other purposes of the Markland project.

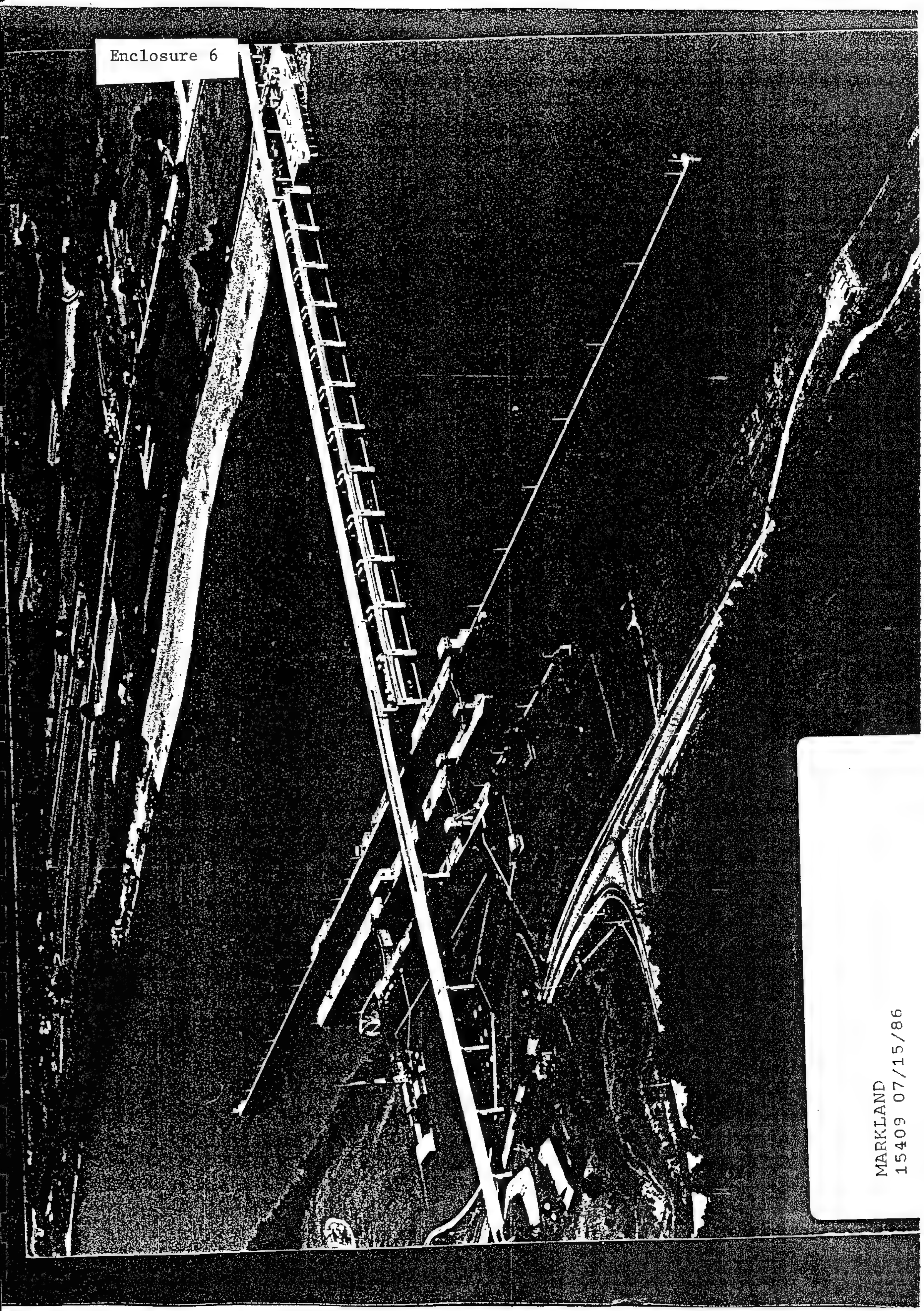


AUTHORITY

The replacement plan for Ohio River Locks and Dams No. 35, 36, 37, 38 and 39 by the Markland Locks and Dam was reviewed by the Board of Engineers for Rivers and Harbors and was approved by the Secretary of the Army on 11 March 1953, all in accordance with the River & Harbor Act approved 3 March 1909.

Construction of the Markland Locks commenced in March 1956 and was completed in April 1959 at which time construction of the new modern high lift dam began. As work progressed on the dam, the old outmoded upstream Locks and Dams 35, 36, 37, 38, and 39 were demolished and the pool progressively raised until maximum pool stage was reached. The dam was finished in the summer of 1963 and the entire facility was placed in operation at this time.

Enclosure 6



Enclosure No. 7

Enclosure 7

CEORL-ED-HD **AUGUST 1995**

MEMORANDUM FOR RECORD

SUBJECT: DEBRIS ACCUMULATION AT OHIO RIVER LOCK INTAKES

The undersigned conducted a study to estimate the quantity of debris accumulation at the culvert intake manifolds at Ohio River Locks. Past dive reports were collected in order to determine the quantity of debris accumulating around the intakes as well as the problems it causes. Also, there was correspondence with the Lock Masters at the facilities investigated to get a feel for the problems they ~~have had~~ with debris. The Ohio River Locks studied include: Markland L&D, McAlpine L&D, Cannelton L&D, Newburgh L&D, and Uniontown L&D. The following is a summary of the findings.

McALPINE LOCKS AND DAM

McAlpine Locks and Dam are located on the Ohio River near Louisville, Kentucky, 606.8 miles below Pittsburgh, Pennsylvania. The locks are located in a bypass canal on the left overbank forming Shippingport Island on the riverward side. The structures, designed to maintain a minimum upper pool during low flows extending about 75 miles upstream to Markland Locks and Dam, include a 1,200-ft lock located at the lower end of a 1.75-mile-long canal along the left bank, one auxiliary lock between the main lock and left bank that is out of service, and one 600-ft auxiliary lock landward that is used during emergencies.

For this study, only the intakes for the operational 1200-ft lock were examined. There are six intake openings in the South Wall (Middle Wall) and eight intake openings in the North Wall (River Wall). Each intake opening is covered by screens made of 2" x ½" vertical bars.

The only records of past dive inspections of intakes were provided by Tom Berry, McAlpine Lockmaster. These included reports from 27 August 1981, 18 November 1982, 13 June 1986, and 15 July 1993.

Both the North and South Wall intakes were inspected on the 25th & 26th of August, 1981. The divers reported that the screens on the north wall were in good condition, however, they reported that drift was a problem and was about 1/4 of the way up from the bottom on most openings. The intakes on the north wall are located in a pit about 18' deep below bedrock. This is an unusual configuration required because of the geology of the Falls of the Ohio. Therefore, there was approximately 110 CY of debris accumulated in the pit. As for the south wall intakes, 3 of the 6 openings were in good condition and the others had bent and worn screens. This manifold is also in a pit about 14' below bedrock. The divers suggested that these openings be reworked.

The intakes on both walls were inspected again in November of 1982. All intake screens were in the same condition as the previous year. However, it was reported that the drift was now about half the way up from the bottom on most openings on the north wall. Therefore, there was approximately 190 CY of debris in the pit.

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The intake openings were inspected in June of 1986 and most of the screens on the south wall needed reworking. On the north wall there were several large logs/trees stuck in the openings and most of the screens were in need of reworking.

The last inspection was completed in July of 1993. All of the screens on both walls were in poor condition with most of the openings ½ full of debris and a few openings completely full of debris.

Although the dive reports show that there is some drift entering the intake openings, the amount is minimized because of the location of the locks in the canal. It is expected that much of the drift and debris bypasses the canal and is carried downstream. Also, mud flats have formed on the Kentucky shore at the entrance to the canal, showing a tendency for sediment to drop out before it reaches the lock. As can be seen in Figures A and B these mud flats are catching some of the debris as it comes downstream before it enters the canal.

CANNELTON LOCKS AND DAM

Cannelton Locks and Dam are located on the Ohio River approximately 720.7 river miles below Pittsburgh, Pennsylvania, and about 3 river miles upstream from Cannelton, Indiana. The structures, designed to maintain a minimum upper pool during low flows extending upstream about 114 river miles to McAlpine L&D, consist of one 1200-ft main lock chamber and 600-ft auxiliary lock located on the left bank (Indiana side) of the river. There are eight intake openings per each of the three lock walls.

Several dive reports between 1982 and 1993 were provided by Jay Davis, Cannelton Lock Master. The findings from each dive inspection were consistent from year to year. The land wall and middle wall intakes stayed approximately a third to a half filled with large logs sticking out of most of the openings. The screens were in bad shape in all of the inspection reports. However, not much drift was found on the river wall. There is approximately 17' of clearance between the bottom of the intakes on the river wall and the river bottom allowing debris to drop to the river bottom when the lock is not filling.

MARKLAND LOCKS AND DAM

The Markland Locks and Dam is located on the Ohio River at mile 531.5 below Pittsburgh, Pennsylvania. The navigation locks are located on the left bank (Kentucky side) of the river. The lock structures include one 1200-ft lock chamber and one 600-ft lock chamber. There are eight intake openings per each of the three lock walls.

On July 20, 1995 a site visit was made to Markland L&D to observe the dewatered 600-ft lock chamber. A significant amount of debris was present in the chamber. An excessive amount of debris has been a trend at Markland L&D. The lock chamber is flushed prior to dewatering, therefore some of the debris was washed out, still leaving an excessive amount. See Figures C and D. Although not all of this debris entered the chamber through the intake openings, it does demonstrate the amount of debris that can be expected at Markland in the future.

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In October of 1993 the screens on the intake openings on the Middle Wall were replaced with newly designed removable intake screens. The new design consists of one large screen that covers all of the intake openings. It can be interchanged to allow repairs to be made on land. On August 7, 1995 a dive inspection was performed to monitor the performance of these new intake screens. Since the screens were installed in 1993, approximately 10' of drift has accumulated across the intake openings.

NEWBURGH LOCKS AND DAM

The Newburgh Locks and Dam is located on the Ohio River near Newburgh, Indiana, at mile 776.1 below Pittsburgh, Pennsylvania. The navigation locks are located on the right bank (Indiana side) of the river. The upper pool maintained above the dam extends upstream for a distance of 55.4 miles to the Cannelton Locks and Dam. The lock structures consist of one 1200-ft lock and one 600-ft lock. There are eight intakes per each of the three lock walls.

Dive inspection reports concerning the intakes could not be located for Newburgh locks. According to Bob Vanwinkle, Lockmaster at Newburgh L&D, the intake screens on the landwall and middle wall were replaced in 1991. In order to change the screens they had to clam out about 4' of debris and sedimentation to get to the openings. Although debris is partially blocking the openings on the intakes, Mr. Vanwinkle noted that there was no noticeable problem with the filling time of the locks.

UNIONTOWN

The Uniontown Locks and Dam is located on the Ohio River about 3-1/2 miles downstream from Uniontown, Kentucky, at mile 846.0 below Pittsburgh, Pennsylvania. The navigation locks are located on the right bank or Indiana side of the river. The upper pool maintained above the dam extends upstream 68.3 miles to the Newburgh Locks and Dam. There are eight intakes per each of the three lock walls. On the middle wall, 4 intakes are located on the 1200-ft side of the wall and the other 4 on the 600-ft side of the wall.

According to Gary Daws, Lockmaster at Uniontown L&D, Uniontown does not get as much debris as other locks because of the bends in the river upstream of the locks. Much of the debris coming downstream builds up in these bends in the river, therefore never reaching the locks. Also, there is no noticeable problems with filling time.

A dive inspection was performed on the intake screens on the land, middle, and river wall in August of 1994. Several screen bars needed replacing on all of the intakes. On the land wall, it was noted in the dive report that it would be necessary to clam shell around the intakes to remove heavy drift and mud in bottom quarter of the intakes. There was some mud and drift in the middle wall intake openings, but the divers had about 4' of clearance from the bottom and did not need these intakes clammed out. The river wall intakes were in similar condition to the middle wall intakes with some clearance below the intakes. They did not require any digging out to replace screens.

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CONCLUSIONS

The amount of debris accumulation around intakes can depend on the orientation and location of the locks as well as the amount of clearance between the inverts and the river bottom. Table 1 shows the invert elevations and river bottom elevations for the locks investigated in this study.

Cannelton Locks and Markland Locks tend to have a significant amount debris because of the location of the locks in the outside of mild bends in the river. These locks were designed to allow barge traffic to have easy access to the lock chamber by allowing them to stay on their flow path. Unfortunately, this also allows drift and debris floating downstream to enter the lock approach.

In the past, Uniontown, Newburgh and McAlpine have not had a significant problem with debris. There are two significant bends in the river just upstream of Uniontown L&D at which some of the drift being carried downstream accumulates near the bank, never reaching the locks. Newburgh L&D does not have a straight approach for the barges, therefore the debris does not either. And as discussed earlier, McAlpine Locks are located at the end of a long canal. Much of the debris bypasses the canal and is carried downstream.

In the past, there has been no scheduled maintenance on the intakes, as far as removing debris from around them. The trend has been that only on occasion when the screens need repairing and the divers cannot get to them are the intakes clammed out. However, the acting Lockmaster at Markland L&D has requested that the intakes be clammed out every two years. This may be necessary at Markland and Cannelton, but the other locks would probably require less. From the findings of this research, possibly every five years would suffice.

Based on rough estimates, the proposed McAlpine Lock intake can expect to attract about half of the 160 CY of material now accumulating at the intakes of the existing 1200-ft lock every year. Any under-the-sill intake design at Markland or Cannelton could be expected to attract about 200 CY per year. The trough to be provided for debris accumulation at McAlpine would hold about ~~100~~ CY below the invert of the intake.
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Jane E. Howell
Civil Engineer

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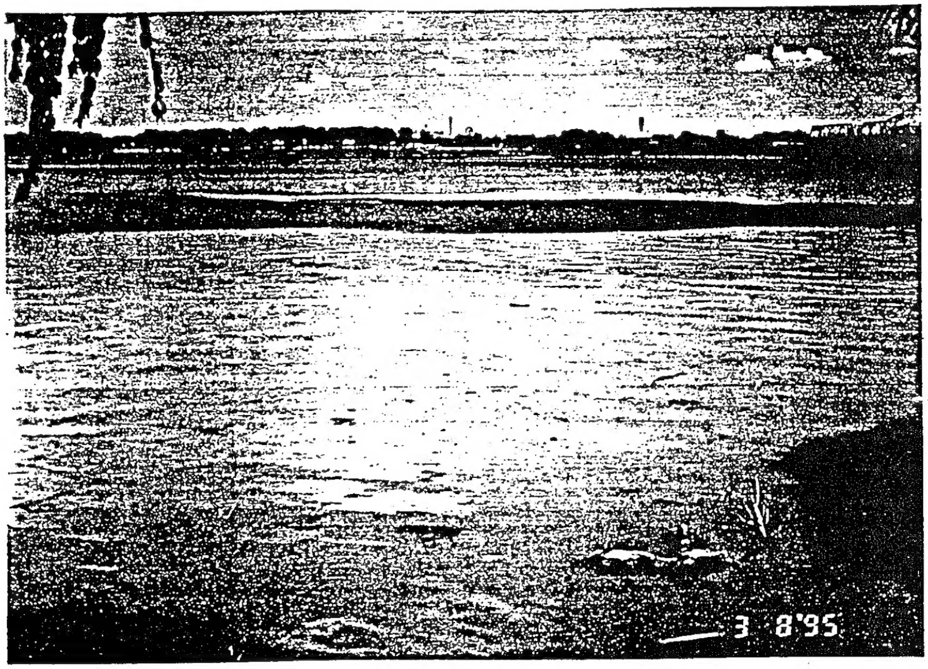

FIGURE A - MUD FLATS UPSTREAM OF MCALPINE L&D
(looking toward Indiana shore)

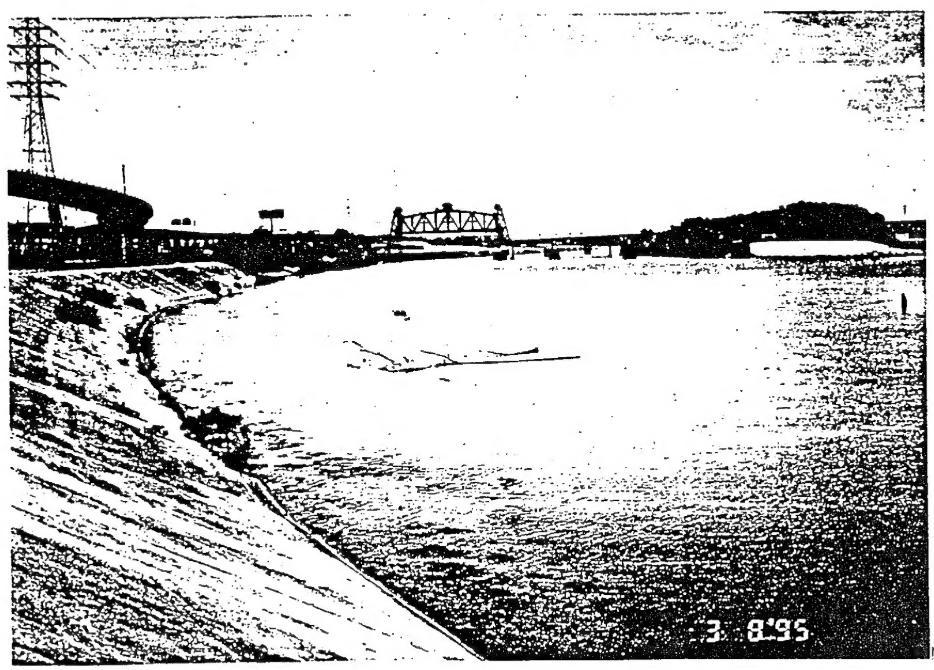

FIGURE B - MUD FLAT UPSTREAM OF MCALPINE WITH DEBRIS ACCUMULATION
(looking downstream toward canal)

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FIGURE C - DEBRIS ACCUMULATION - MARKLAND 600-FT LOCK CHAMBER
(looking down into the lock)

FIGURE D - DEBRIS ACCUMULATION - MARKLAND 600-FT LOCK CHAMBER
(view from down in the lock chamber)

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TABLE 1

CANNELTON LOCKS AND DAM				
LOCATION OF CULVERT INTAKE MANIFOLDS	LAND WALL, MIDDLE WALL, OR RIVER WALL	INVERT ELEVATION	RIVER BOTTOM ELEVATION	DEPTH BELOW INTAKES
U.S. INTAKE STA. 1+01.75A - D.S. INTAKE STA. 0+28.25A	MIDDLE WALL	349	346	3'
U.S. INTAKE STA. 0+84.50A - D.S. INTAKE STA. 06.50A	LAND WALL	349	346	3'
U.S. INTAKE STA. 1+01.75A - D.S. INTAKE STA. 0+28.25A	RIVER WALL	349	325	24'
MARKLAND LOCKS AND DAM				
LOCATION OF CULVERT INTAKE MANIFOLD	LAND WALL, MIDDLE WALL, OR RIVER WALL	INVERT ELEVATION	RIVER BOTTOM ELEVATION	DEPTH BELOW INTAKES
U.S. INTAKE STA. 3+54.5A - D.S. INTAKE STA. 2+75.5A	MIDDLE WALL	421	414	7'
U.S. INTAKE STA. 3+25.5A - D.S. INTAKE STA. 2+26.5A	LAND WALL	421	414	7'
U.S. INTAKE STA. 3+54.5A - D.S. INTAKE STA. 2+75.5A	RIVER WALL	421	404	17'
MCALPINE LOCKS AND DAM				
LOCATION OF CULVERT INTAKE MANIFOLD	LAND WALL, MIDDLE WALL, OR RIVER WALL	INVERT ELEVATION	RIVER BOTTOM ELEVATION	DEPTH BELOW INTAKE (TO PIT BOTTOM)
U.S. INTAKE STA. 4+50A - D.S. INTAKE STA. 5+00A	MIDDLE WALL (1200' SOUTH WALL)	384	398	4'
U.S. INTAKE STA. 8+50A - D.S. INTAKE STA. 9+45A	RIVER WALL (1200' NORTH WALL)	381	399	4'
NEWBURGH LOCKS AND DAM				
LOCATION OF CULVERT INTAKE MANIFOLD	LAND WALL, MIDDLE WALL, OR RIVER WALL	INVERT ELEVATION	RIVER BOTTOM ELEVATION	DEPTH BELOW INTAKES
U.S. INTAKE STA. 1+43.08A - D.S. INTAKE STA. 1+62.08A	MIDDLE WALL	325.5	323.5	2'
U.S. INTAKE STA. 2+09A - D.S. INTAKE STA. 2+49A	LAND WALL	325.5	323.5	2'
U.S. INTAKE STA. 2+07A - D.S. INTAKE STA. 2+47A	RIVER WALL	325.5	323.5	2'
UNIONTOWN LOCKS AND DAM				
LOCATION OF CULVERT INTAKE MANIFOLD	LAND WALL, MIDDLE WALL, OR RIVER WALL	INVERT ELEVATION	RIVER BOTTOM ELEVATION	DEPTH BELOW INTAKES
U.S. INTAKE STA. 1+40A - D.S. INTAKE STA. 1+80.83A	MIDDLE WALL	307.5	306	1.5'
U.S. INTAKE STA. 2+06A - D.S. INTAKE STA. 2+93A	LAND WALL	307.5	306	1.5'
U.S. INTAKE STA. 2+04A - D.S. INTAKE STA. 2+91A	RIVER WALL	307.5	306	1.5'

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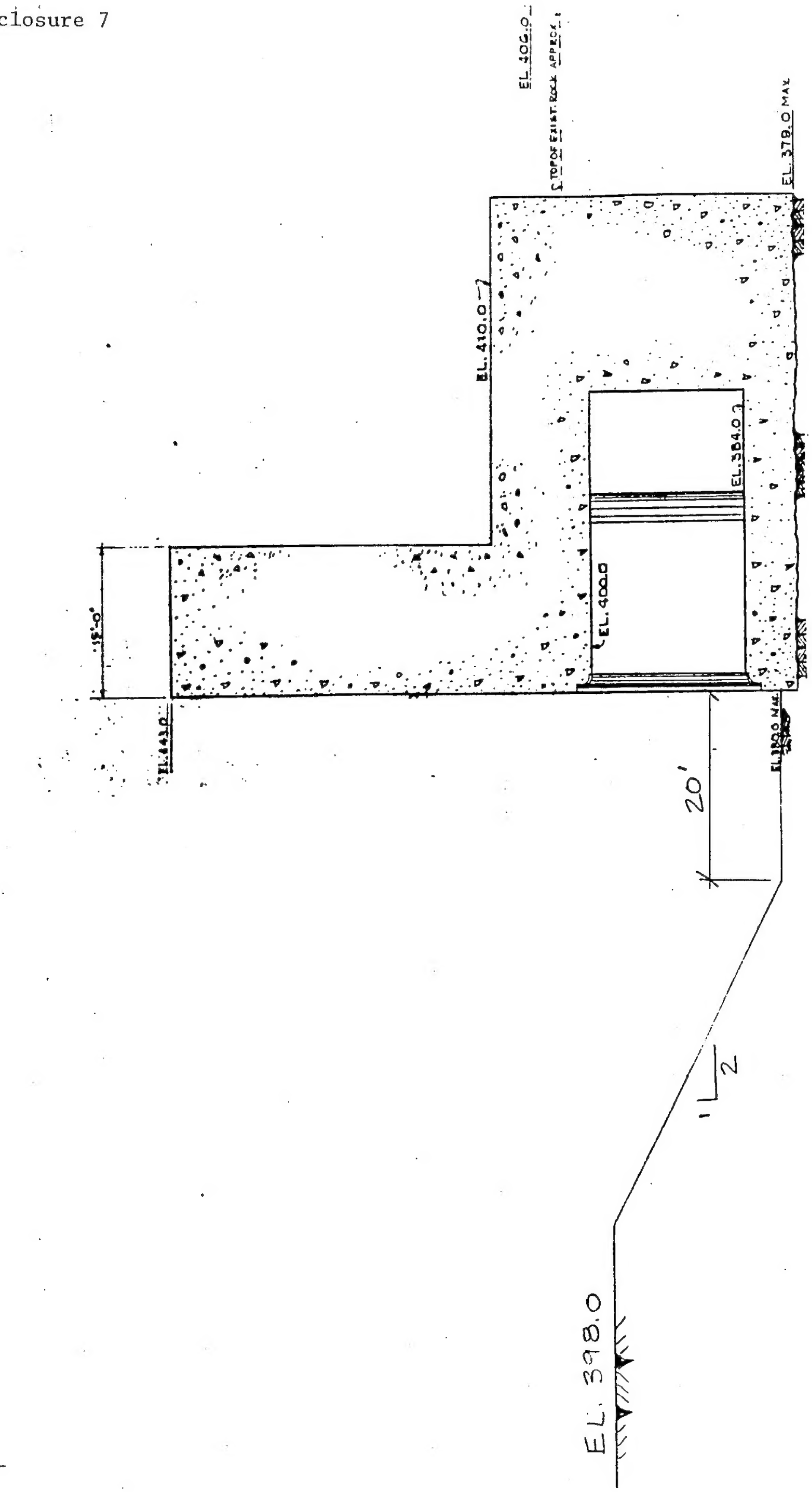

SECTION A-A